

Climate Science, Change, and Adaptation Overview

Presented to
Delta Stewardship Council

Presented by
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DELTA STEWARDSHIP COUNCIL

September 2010

Outline

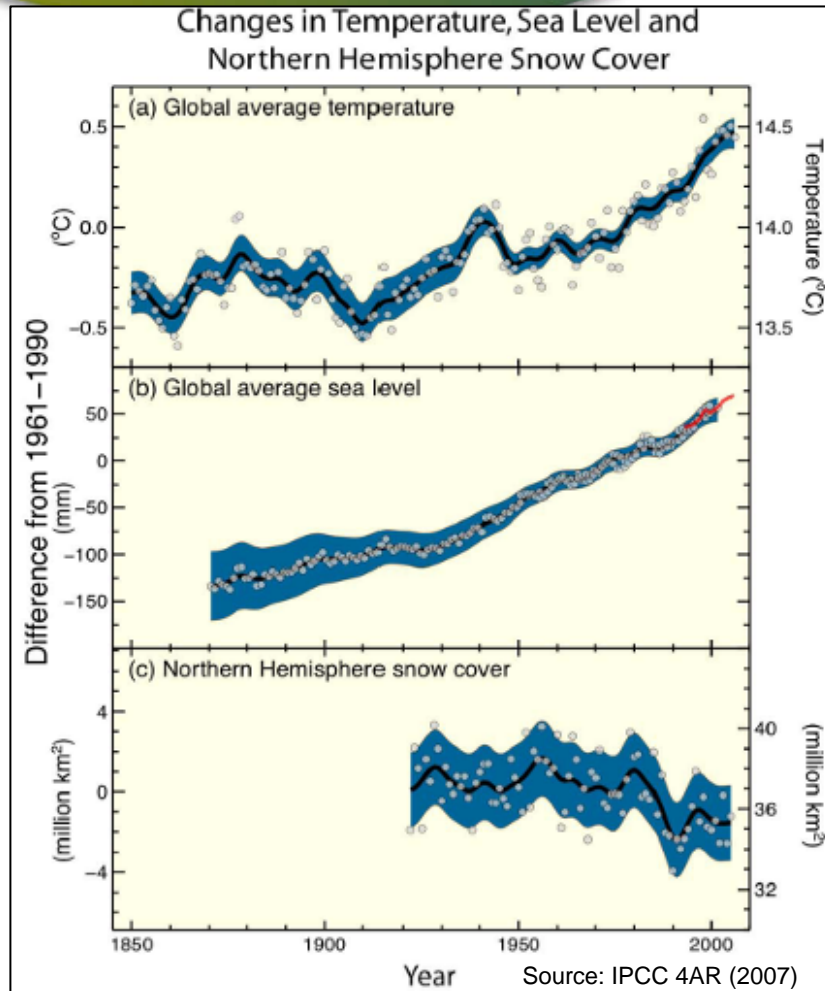
- What does the observational science show?
- What are the projected changes in climate?
- Global versus regional scales
- Incorporating climate information to assess vulnerabilities
- Key risk areas and adaptation planning

Observed Climate Change



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Climate changes are already underway: Observed changes at global scale



Global surface temperature increased 1.33 ± 0.32 °F during the 100 years ending in 2005 (IPCC 2007)

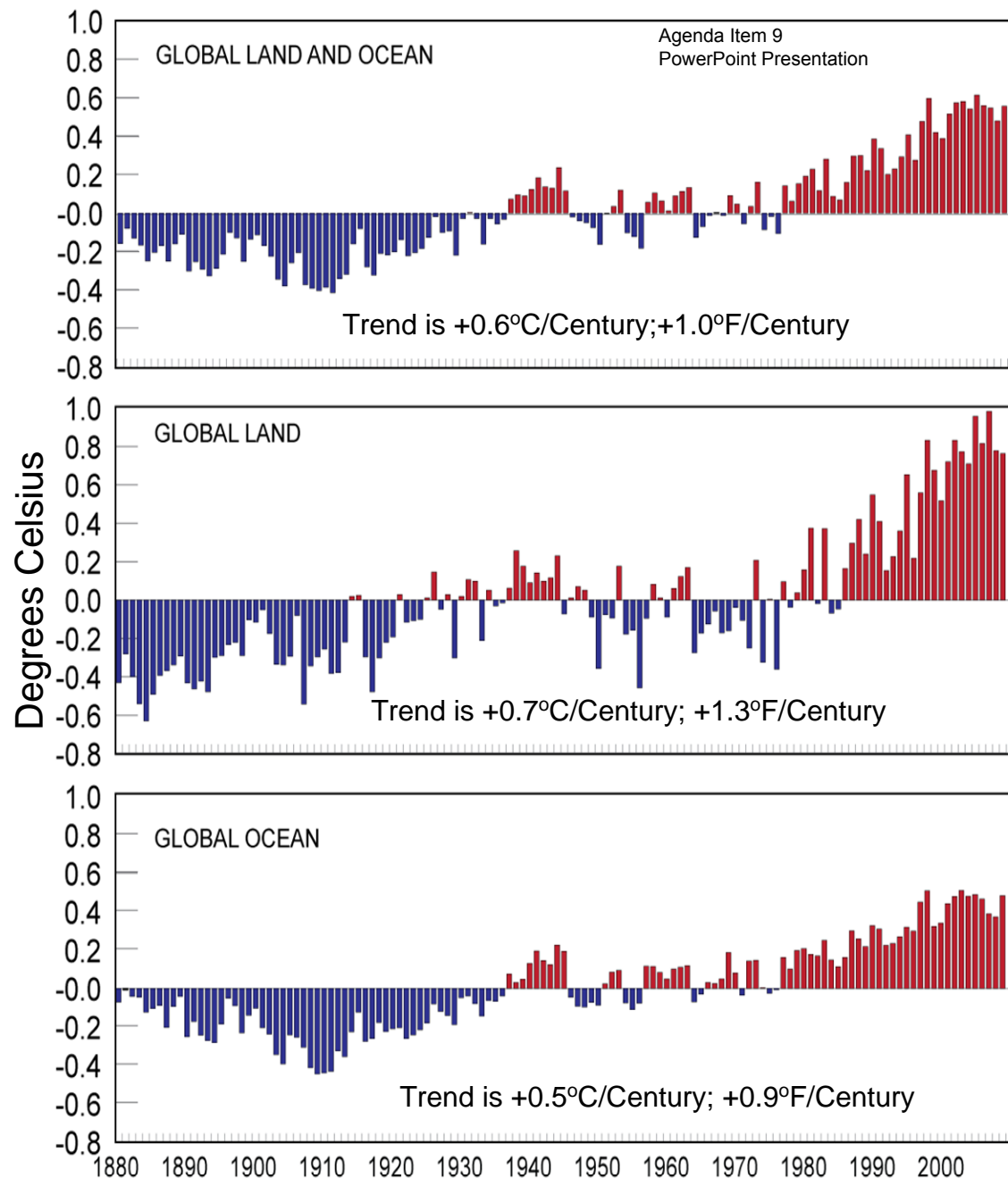
Sea level has risen 7.7 inches from 1870-2004 (Church 2006)

Northern Hemisphere snow cover has decreased by 1.7% relative to (1961-2000) (IPCC 2007)



Jan-Dec Global Surface Average Temperature Anomalies

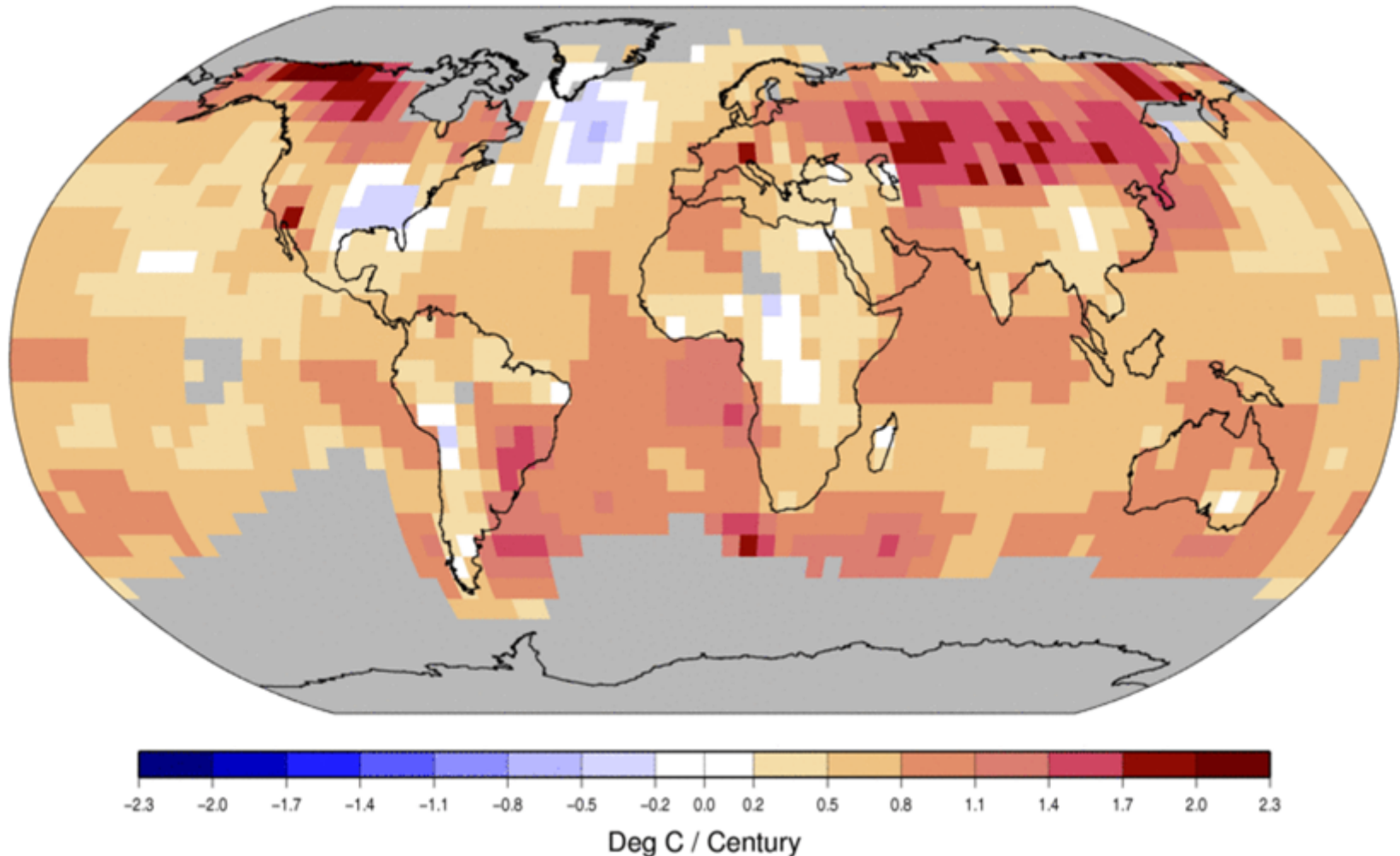
- Surface warming is considerably higher than oceans
- Oceans are absorbing heat, contributing to thermal expansion (sea level rise)



NCDC/NOAA/NESDIS (Smith *et al.*, 2008)

Global Warming is not Uniform Around the Globe

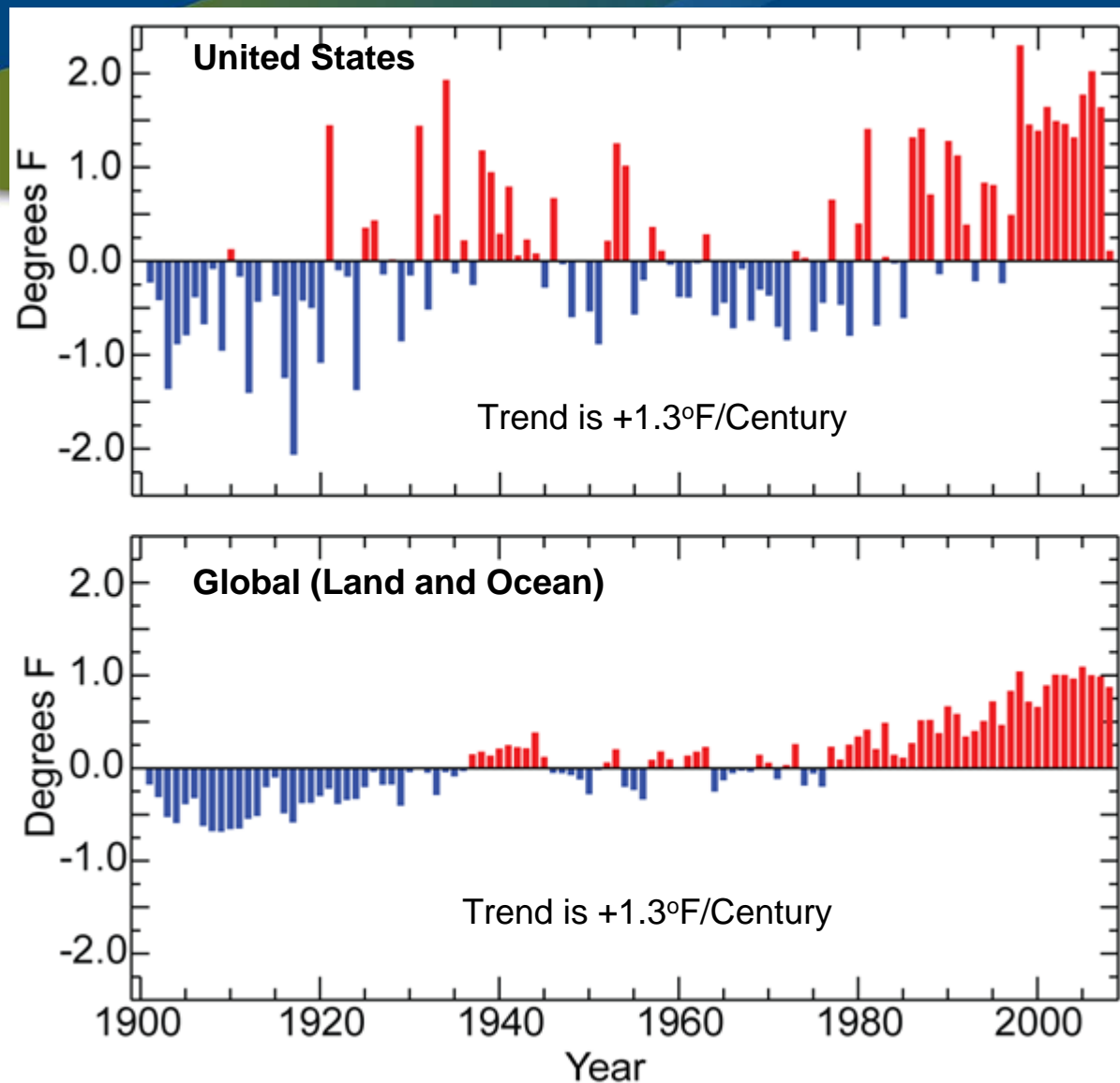
Trend in Annual TMEAN, 1900 to 2009



Annual Average Temperature

(Departure from the 1901-2000 Average)

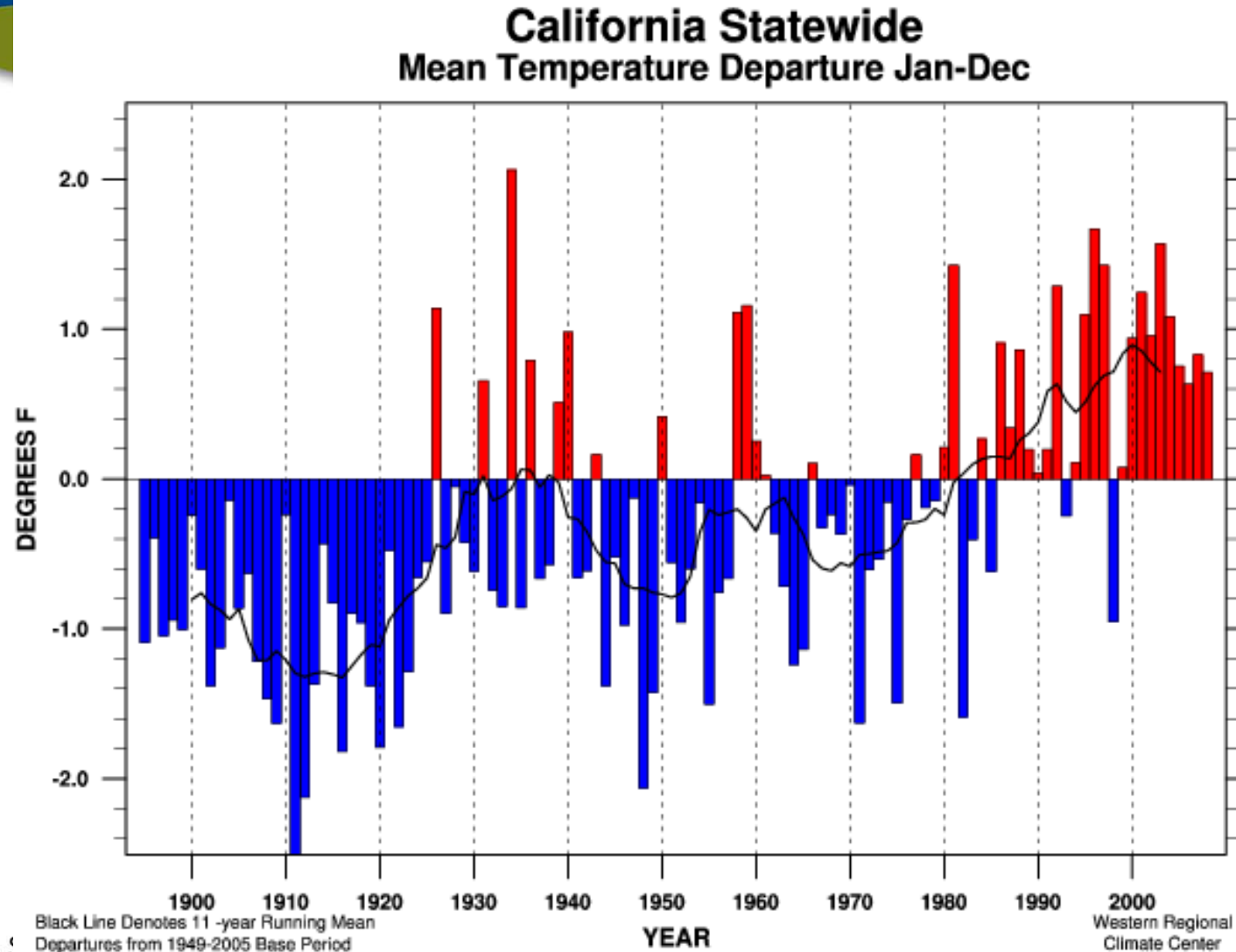
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NCDC/NOAA/NESDIS
(Smith *et al.*, 2008)

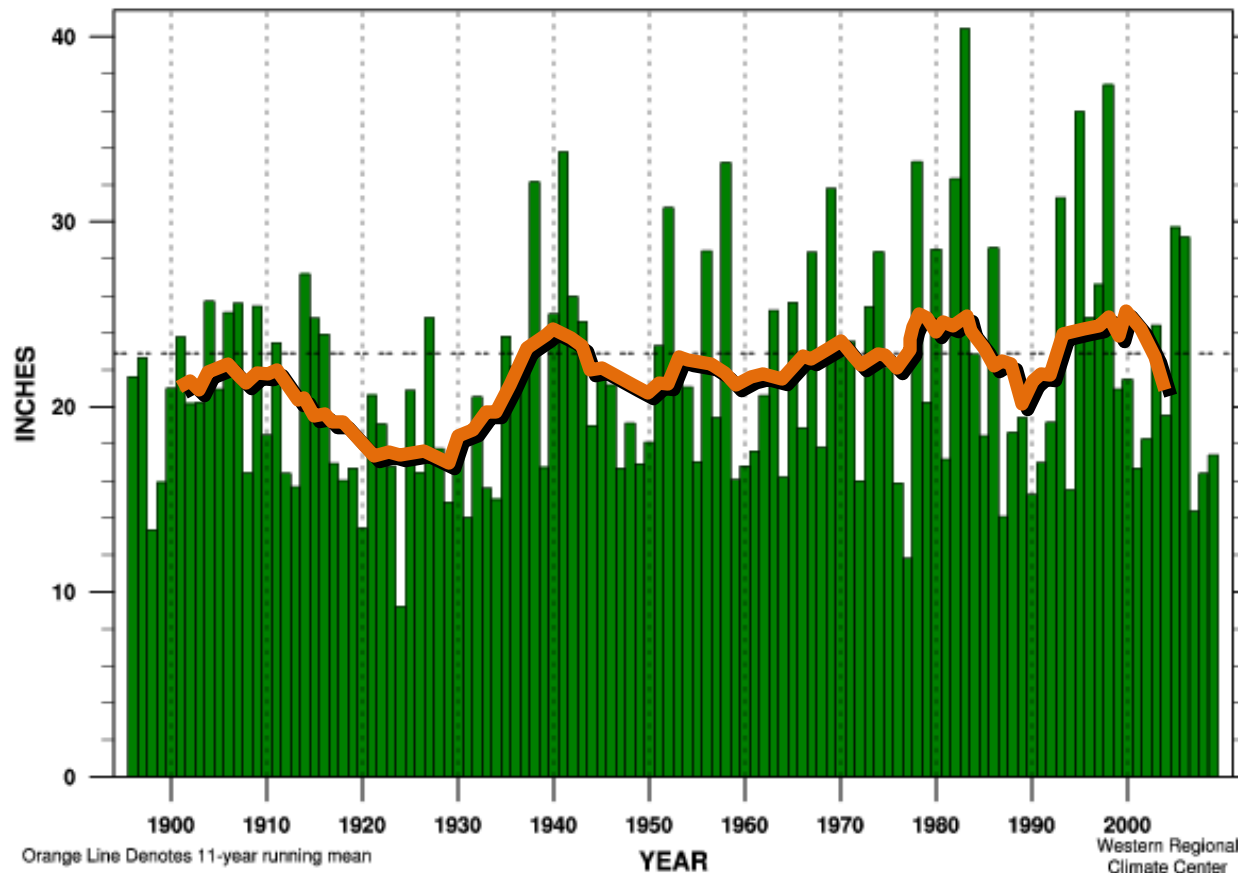


California Warming Trend is Similar to Global

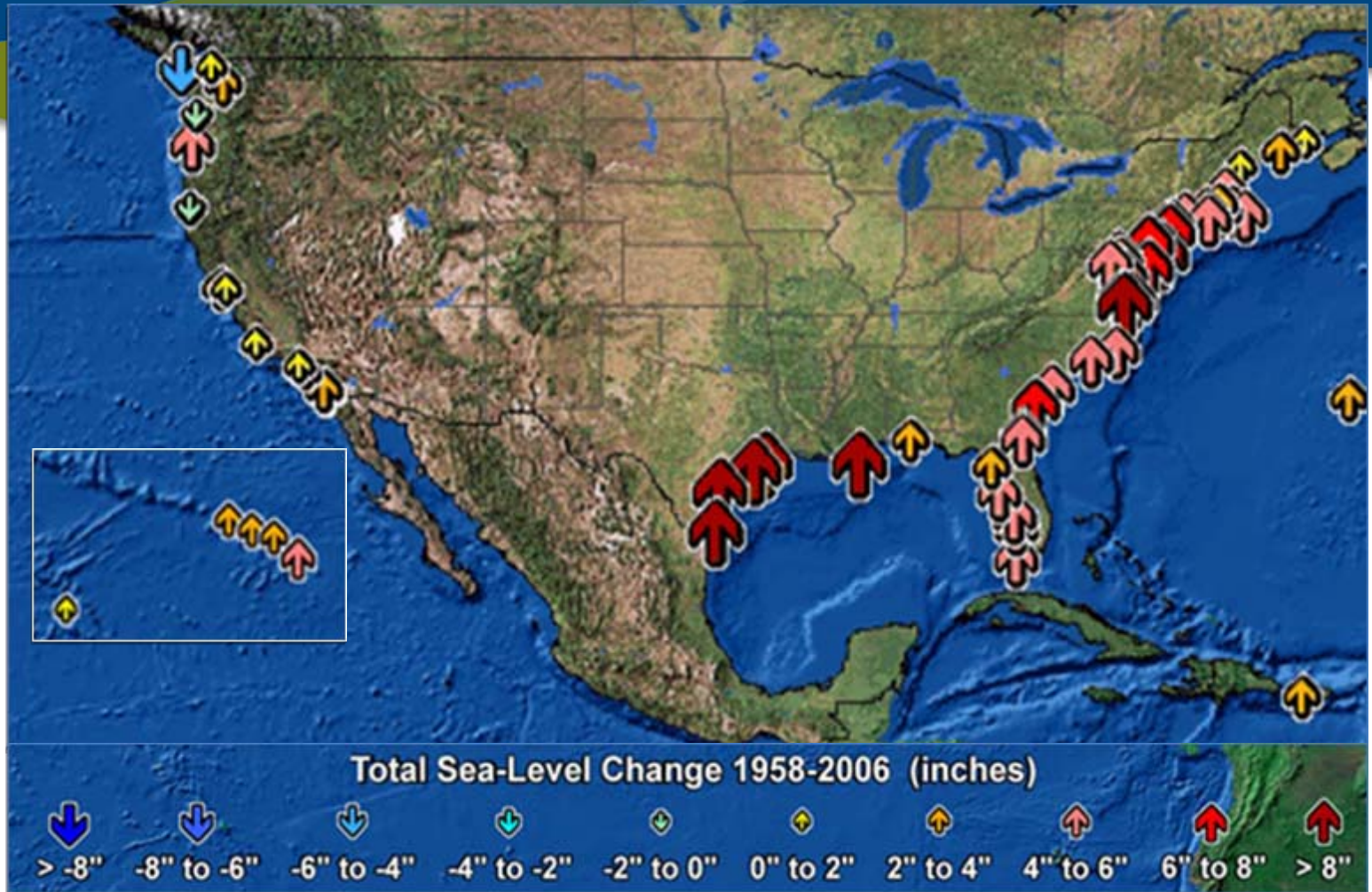


California Precipitation is Highly Variable, Trends are Weaker

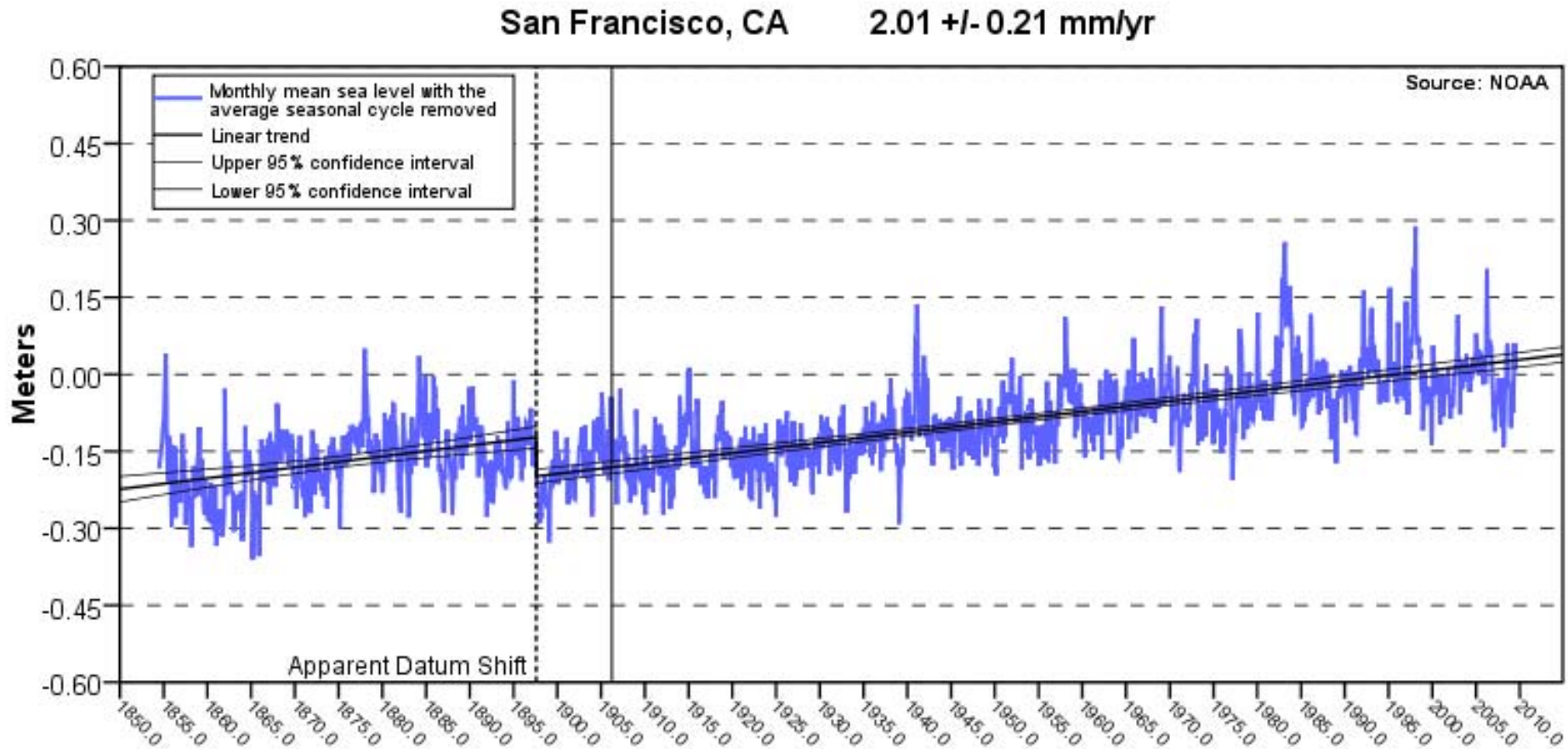
California Statewide Precipitation (Oct-Sep.)



U.S. Sea Level Rise Trends

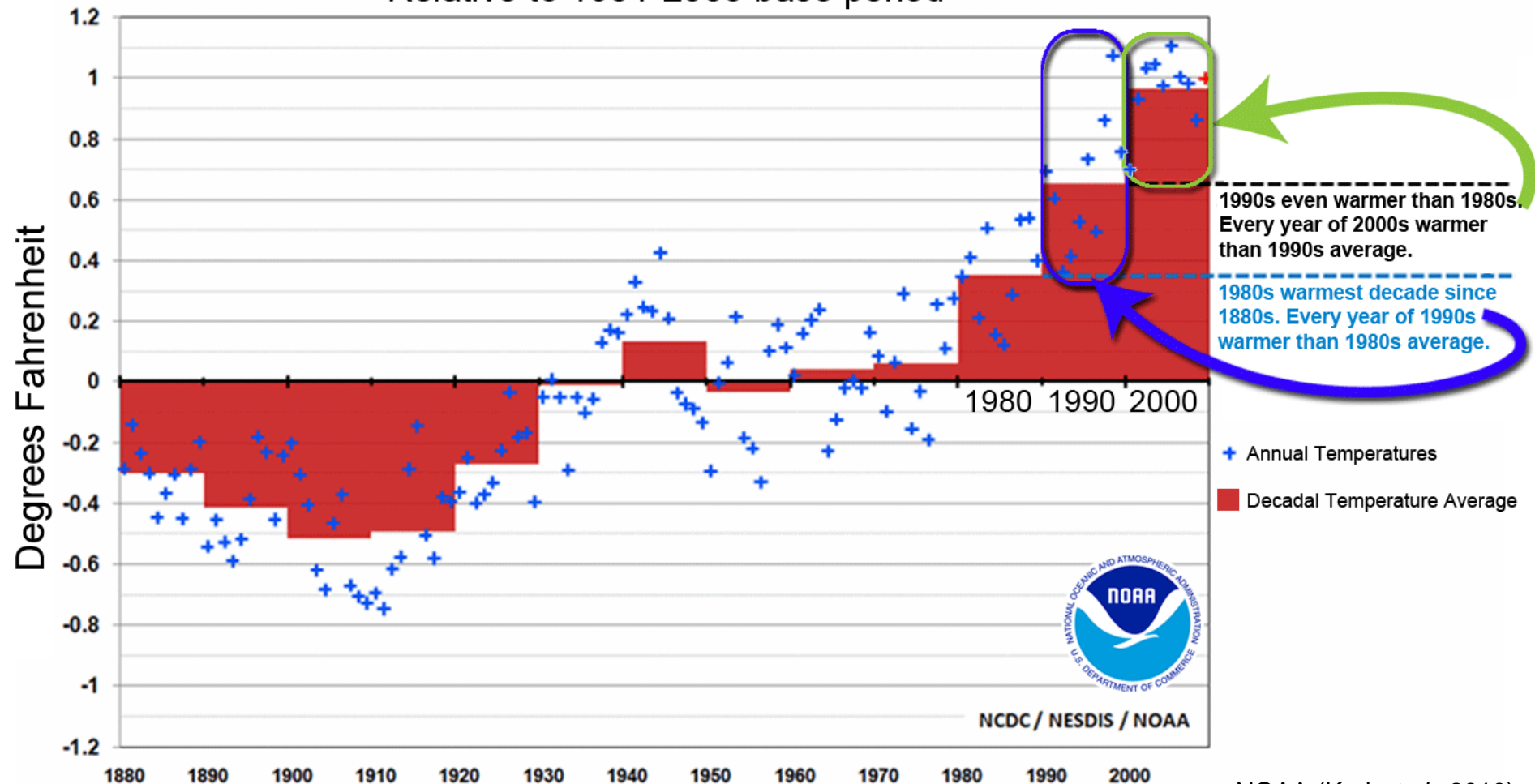


Observed Sea Level Trends



Has Global Warming Stopped?

Annual Global (Land & Ocean Temperature Anomaly)
Relative to 1901-2000 base period



NOAA (Karl *et al.*, 2010)

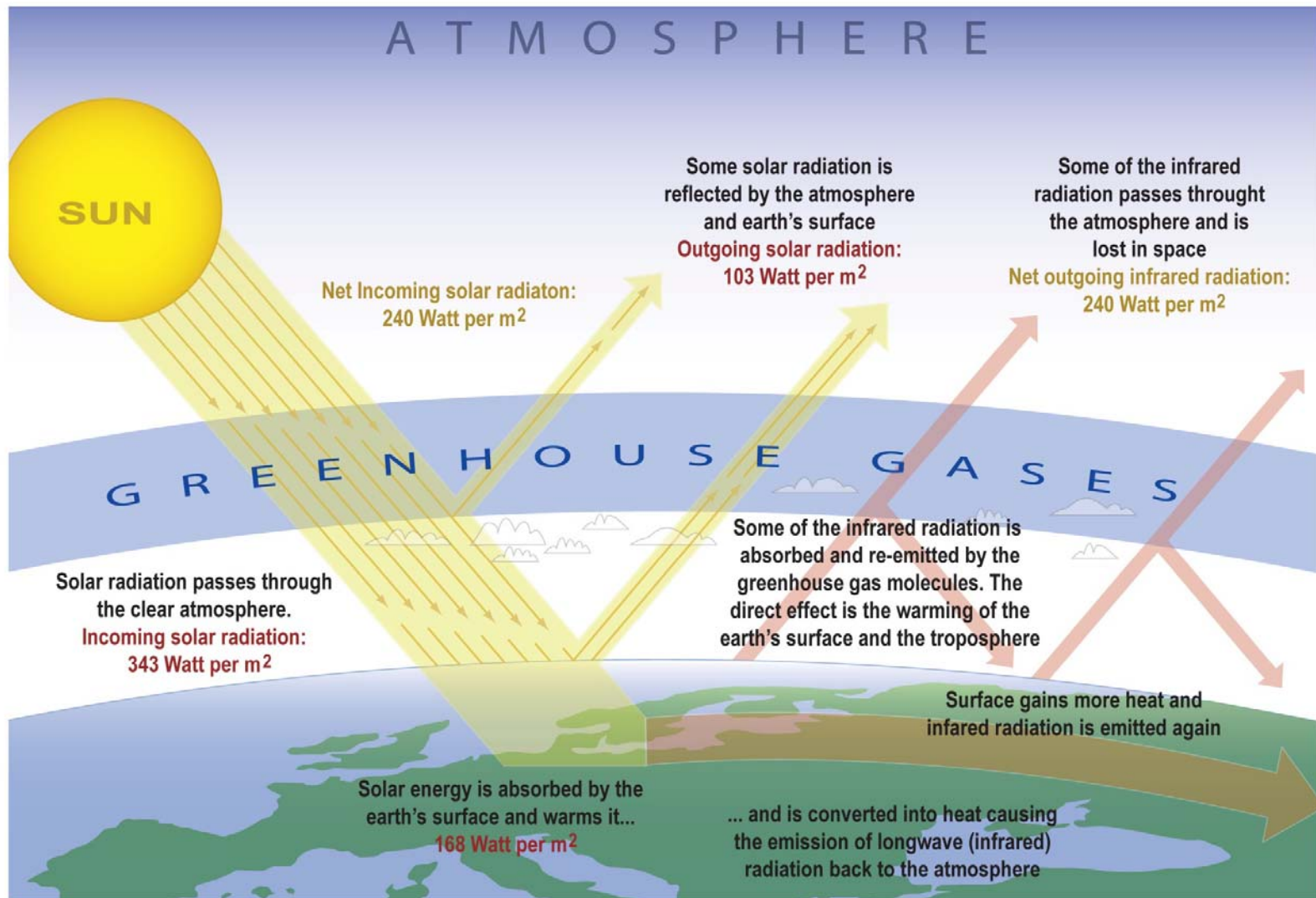
Projections of Future Climate Change



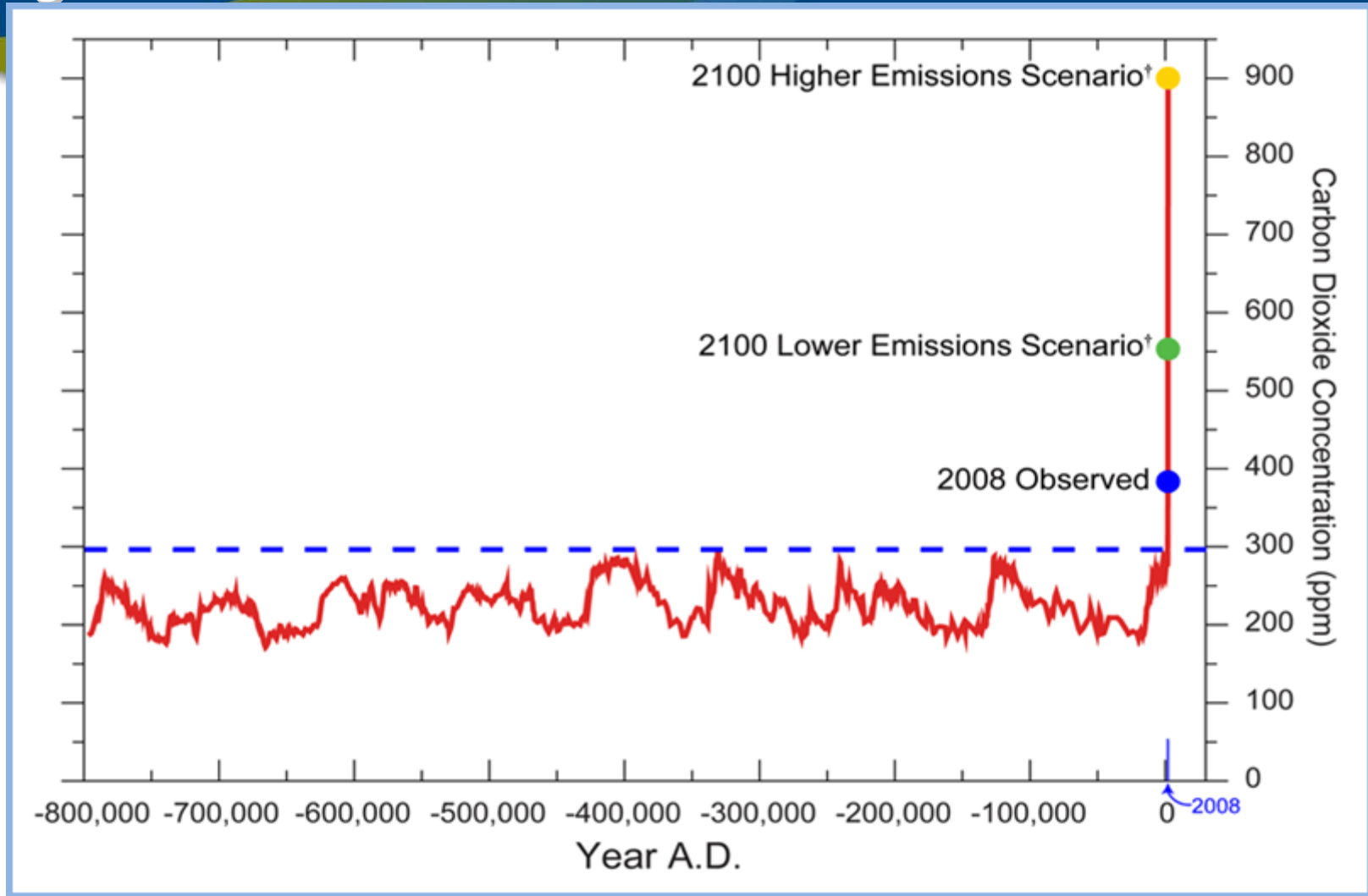
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Greenhouse Gases are a Major Component of Recent Warming

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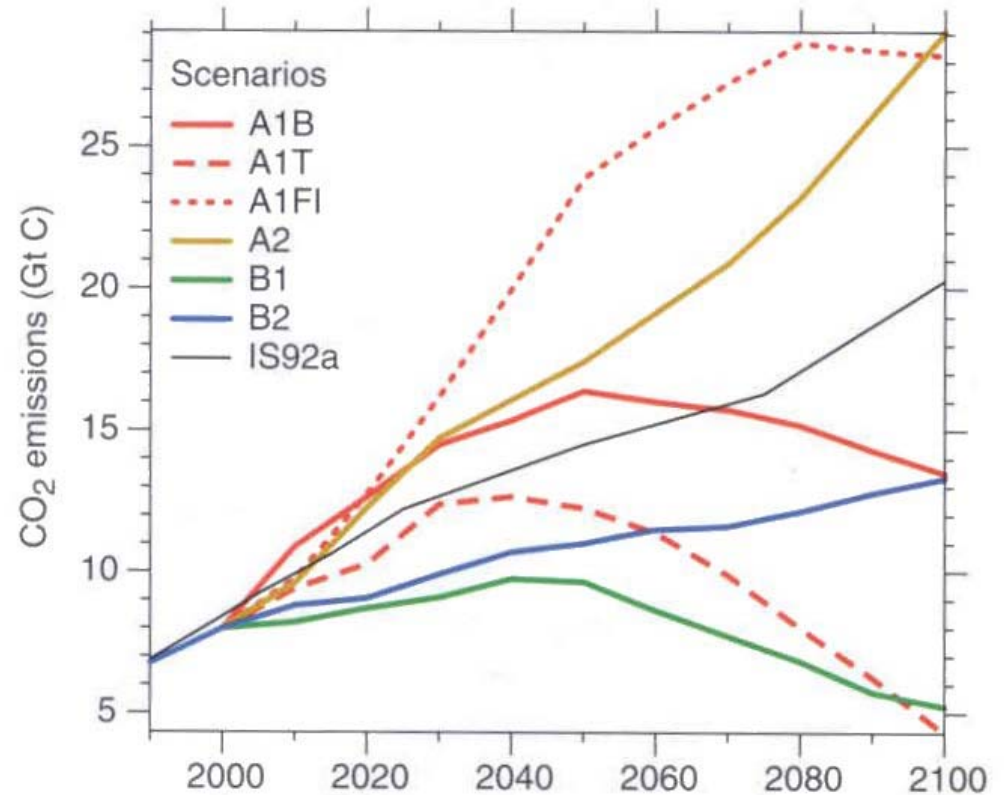
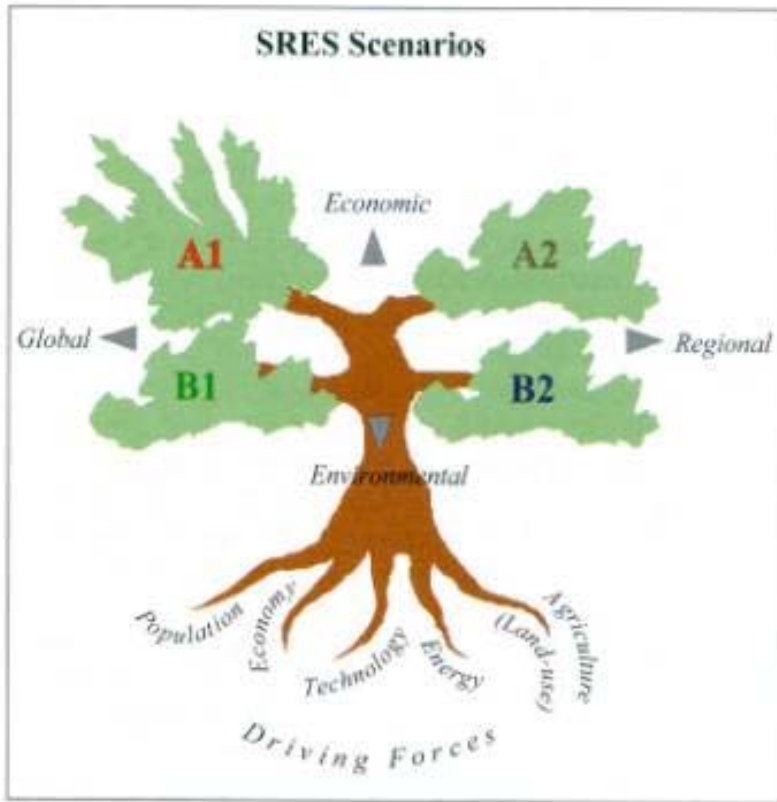


Atmospheric CO₂ is at Levels Significantly Higher than the Past



Projections of Future Climate are Dependent on Emission Scenarios

SRES Scenarios



Source: IPCC 2007

Many Climate Projections Available

Monthly Mean Atmosphere Data Availability

(as of 27 February 2008)

 1 realization

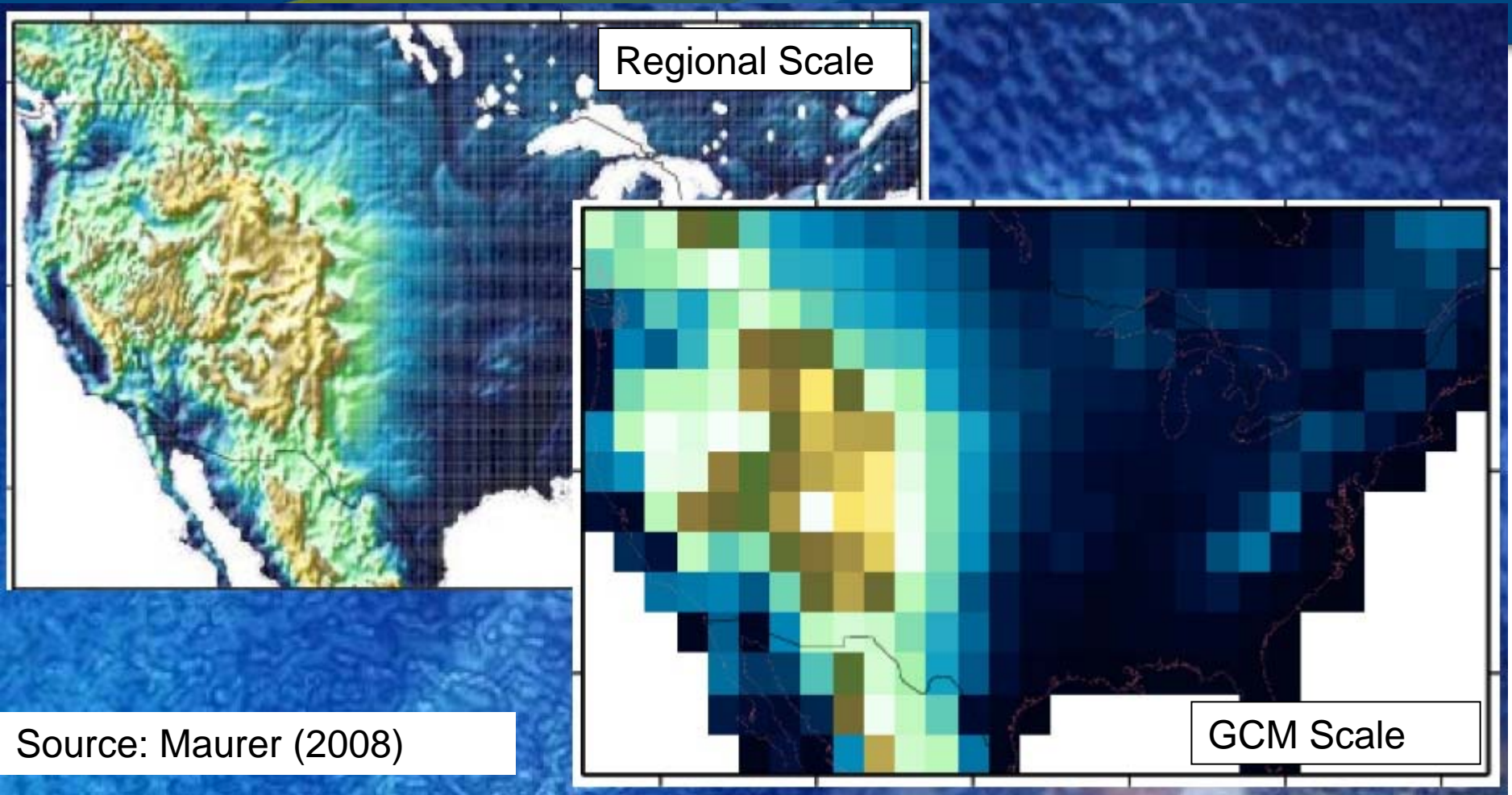
 multiple realizations

	Plcntrl	PDcntrl	20C3M	Commit	SRESA2	SRESA1B	SRESB1	1%to2x	1%to4x	Slabcntl	2xCO2	AMIP
BCC-CM1, China												
BCCR-BCM2.0, Norway	1		1	1	1	1	1	1				
CCSM3, USA	2	1	9	5	5	7	8	1	1	1	1	1
CGCM3.1(T47), Canada	1		5	5	5	5	4	1	1	1	1	
CGCM3.1(T63), Canada	1		1			1	1	1		1	1	
CNRM-CM3, France	1		1	1	1	1	1	1	1			1
CSIRO-Mk3.0, Australia	2		3	1	1	1	1	1		1	1	
CSIRO-Mk3.5, Australia	1		1	1	1	1	1	1				
ECHAM5/MPI-OM, Germany	1		4	3	3	4	3	3	1	1	1	3
ECHO-G, Germany/Korea	1	1	5	4	3	3	3	1	1			
FGOALS-g1.0, China	3		3	3		3	3	3				3
GFDL-CM2.0, USA	1		3	1	1	1	1	1	1	1	1	
GFDL-CM2.1, USA	1		3	1	1	1	1	1	1			
GISS-AOM, USA	2		2			2	2					
GISS-EH, USA	1		5			4		1				
GISS-ER, USA	1		9	1	1	5	1	1	1	1	1	4
INGV-SXG, Italy	1		1		1	1		1	1			
INM-CM3.0, Russia	1		1	1	1	1	1	1	1	1	1	1
IPSL-CM4, France	1	1	2	1	1	1	1	1	1			6
MIROC3.2(hires), Japan	1		1			1	1	1		1	1	1
MIROC3.2(medres), Japan	1		3	1	3	3	3	3	3	1	1	3
MRI-CGCM2.3.2, Japan	1	1	5	1	5	5	5	1	1	1	1	1
PCM, USA	1	1	4	3	4	4	4	5	1			1
UKMO-HadCM3, UK	2		2	1	1	1	1	1				
UKMO-HadGEM1, UK	1		1		1	1		2	1	1	1	1

Program for Climate Model Diagnosis and Intercomparison (2010)

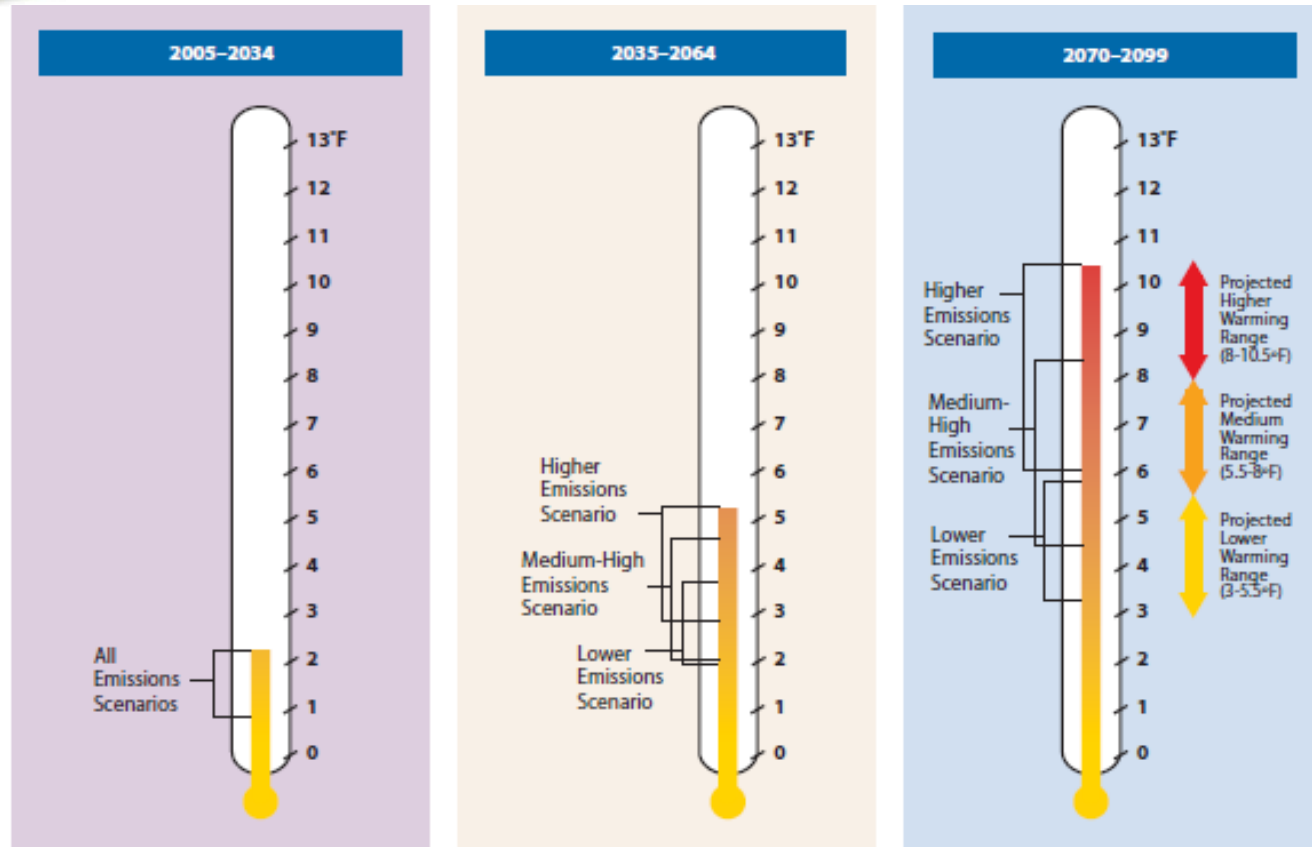


Bringing Global Signals to Regional Scales: Downscaling



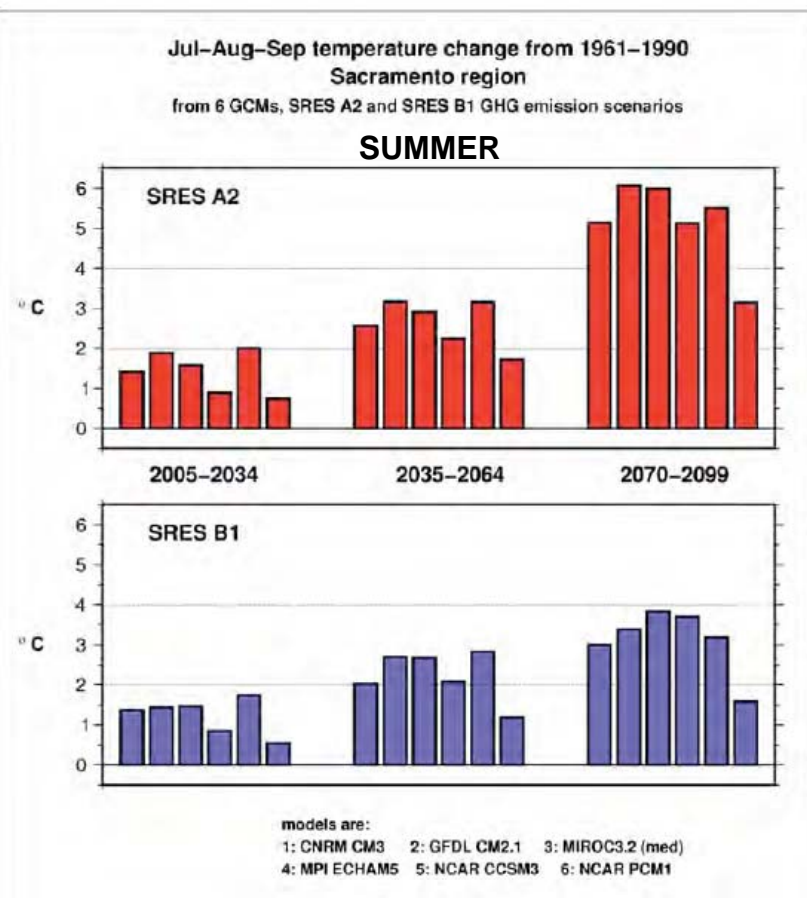
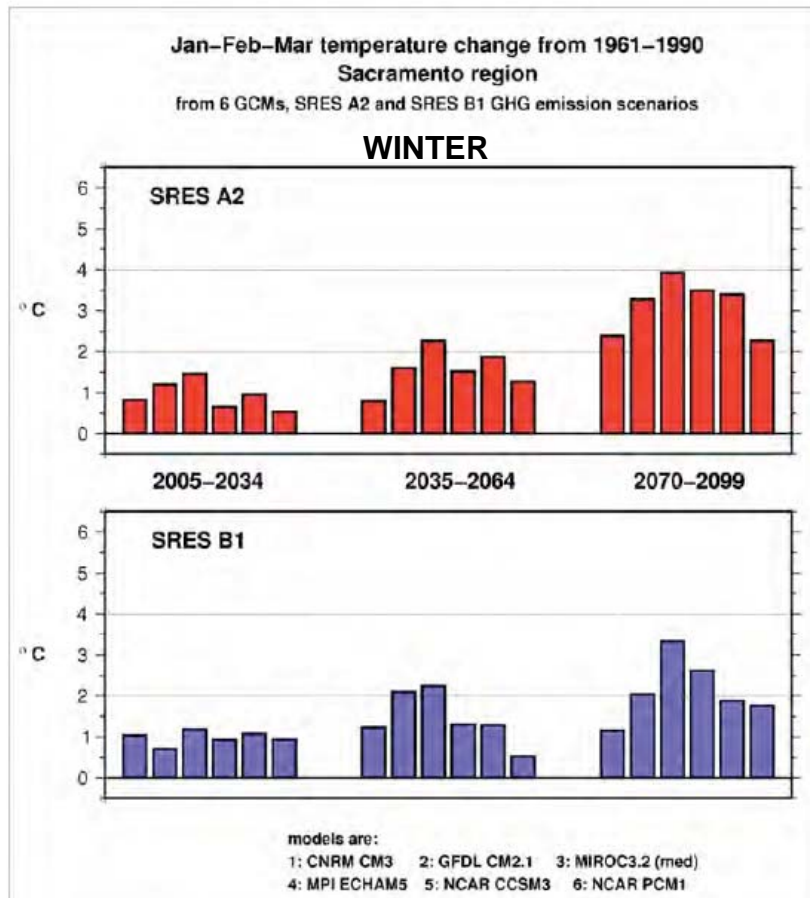
Recent Warming is Projected to Accelerate

- Consistency between scenarios in terms of direction and general magnitude of change
- Relatively small difference between scenarios over the next 30-40 yrs



Source: California Climate Change Center, 2006

Summer warming is significantly higher than winter warming

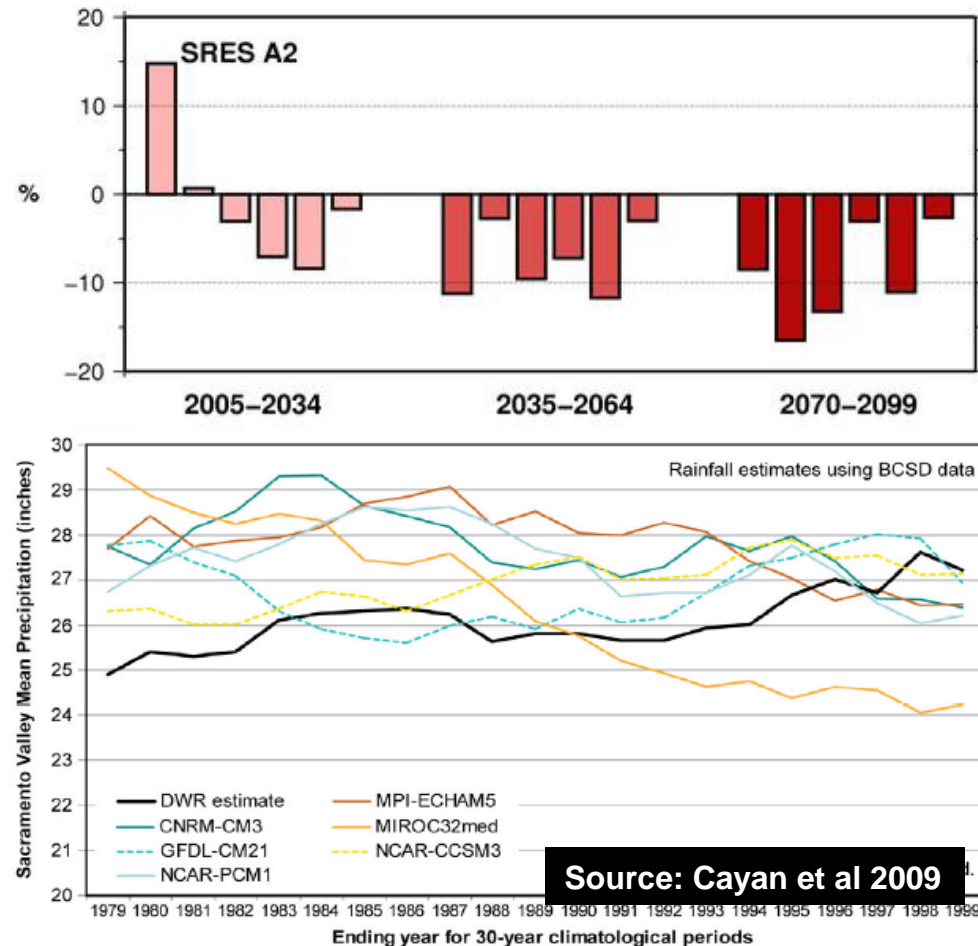


Source: Cayan et al 2009

Projected Precipitation Changes

- Historical precipitation trends not well captured by current GCMs
- Precipitation trend projections have larger uncertainty than temperature
- California Climate Action Team scenarios show drying trend in most models
- Drying trend, however, is not exhibited in all GCMs
- Increasing sea level pressure may be cause of northerly push in storm tracks

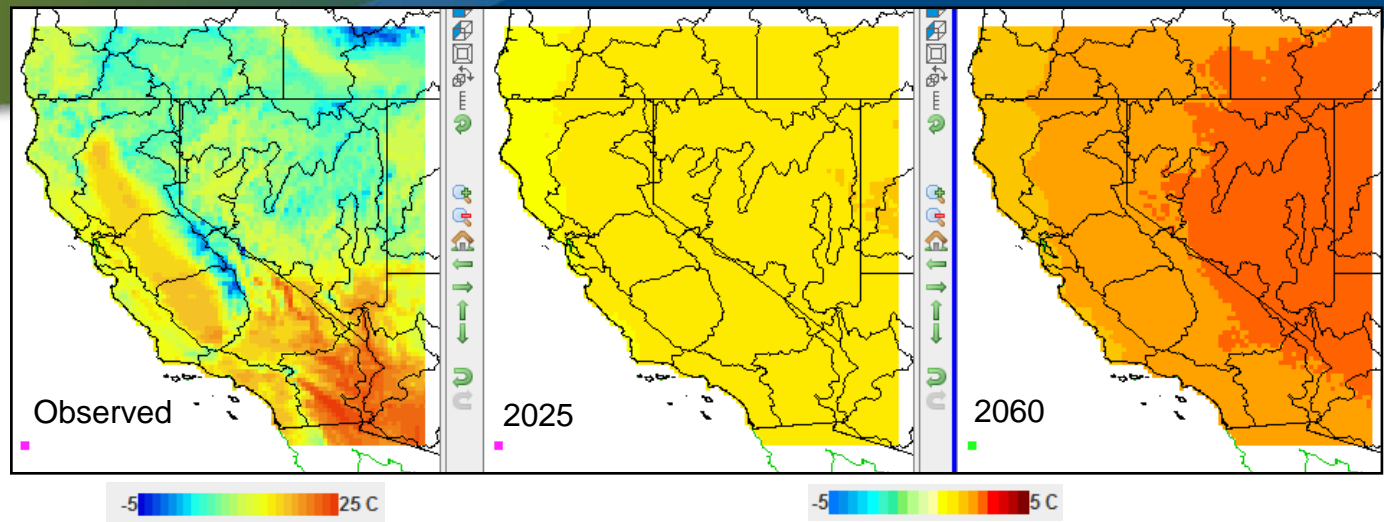
percent of 1961–1990 water year precip
Sacramento region
from 6 GCMs, A2 and B1 GHG emission scenarios



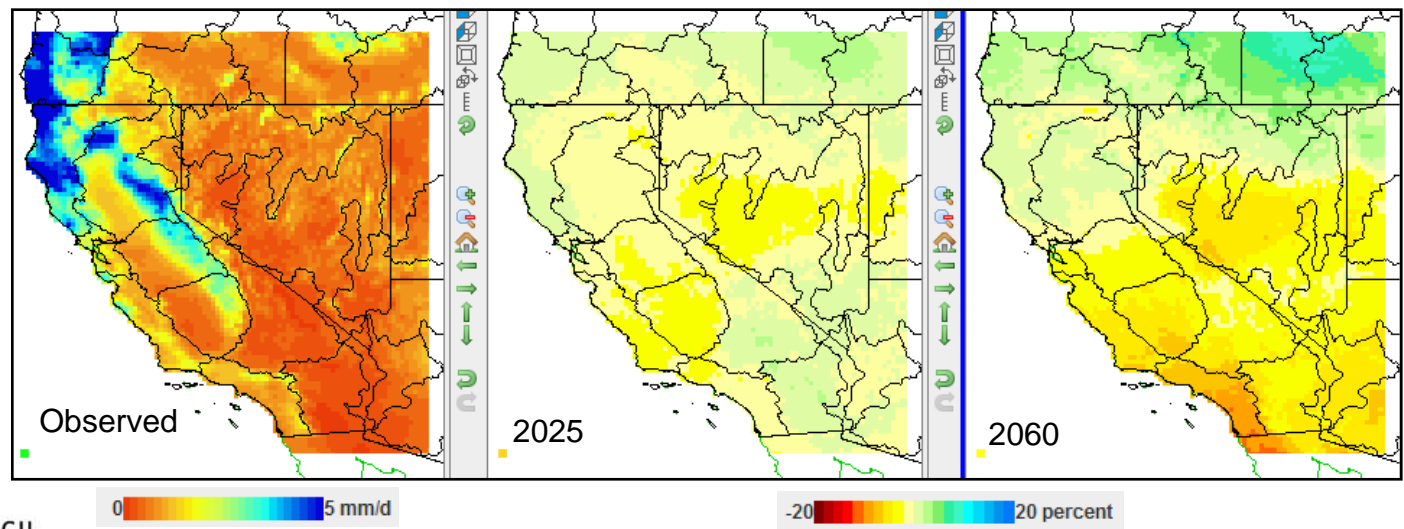
Annual Spatial Change Patterns

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Change in
Annual Mean
Temperature



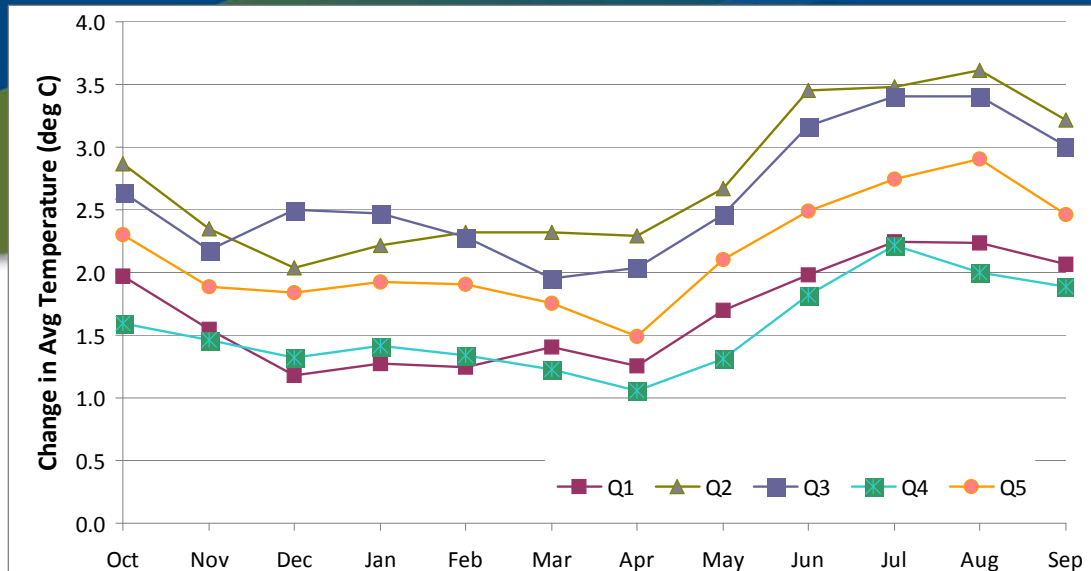
Change in
Annual Mean
Precipitation



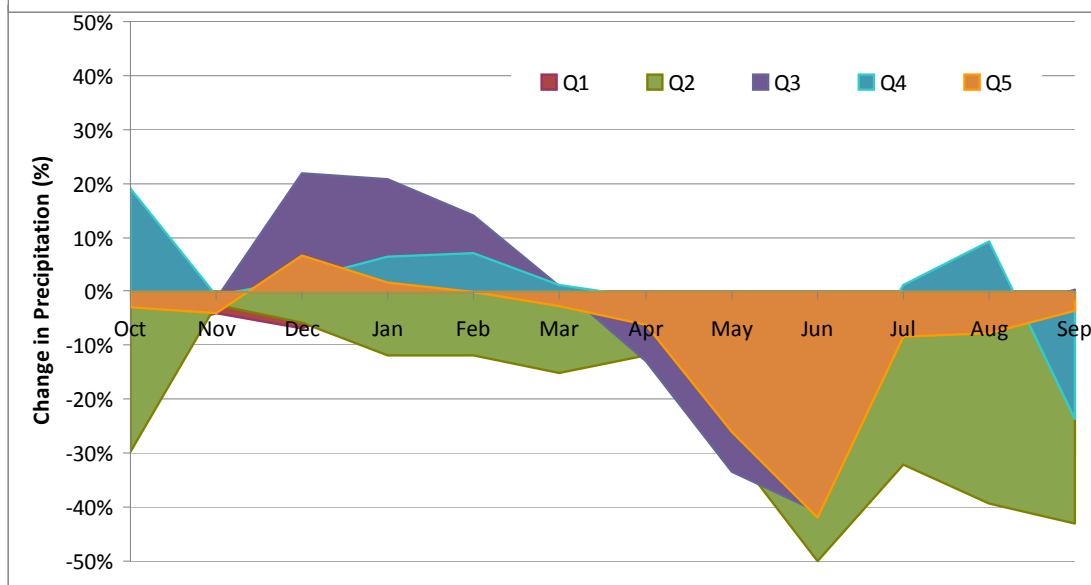
Seasonal Temperature & Precipitation Changes

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Monthly Temperature Changes



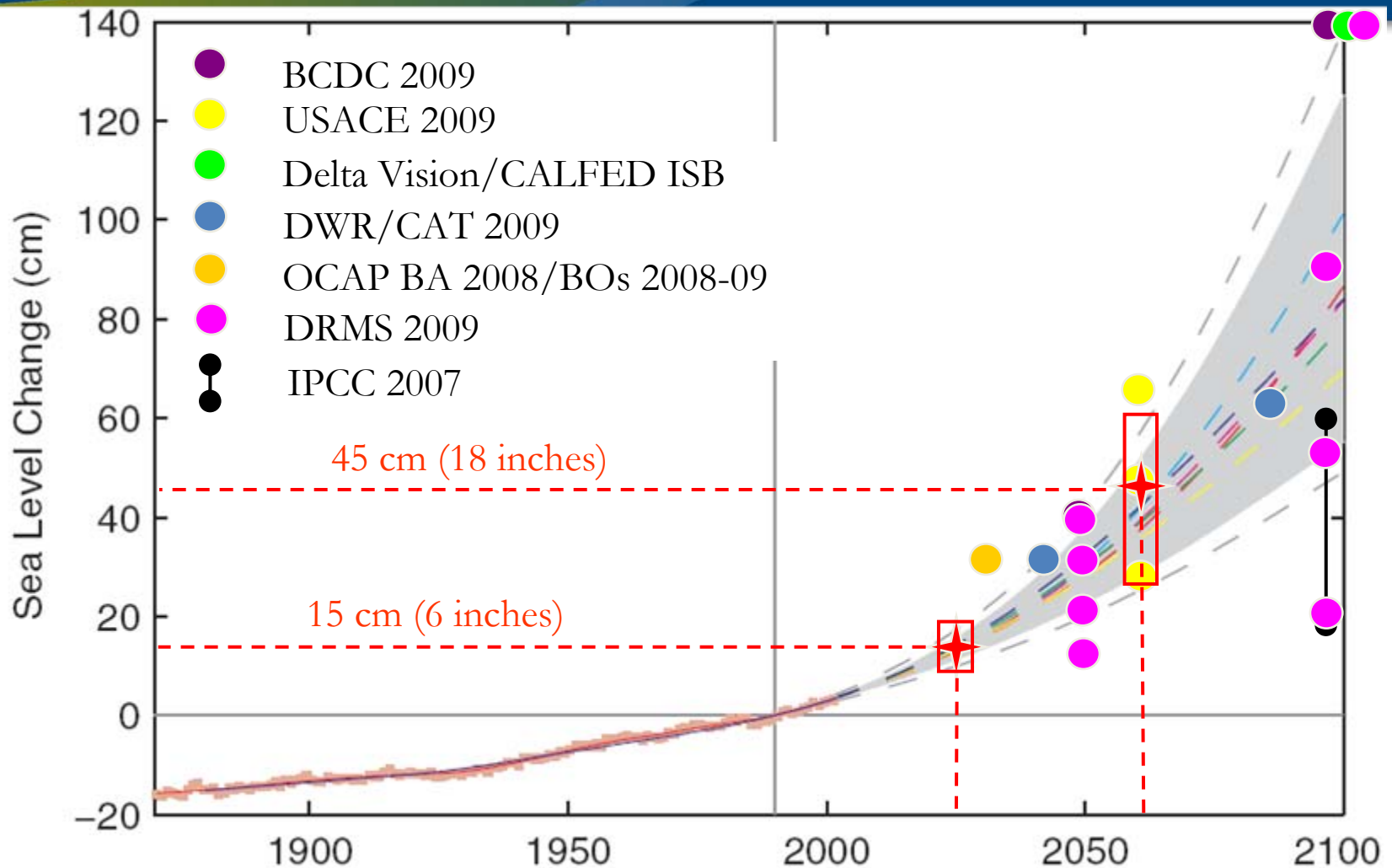
Monthly Precipitation Changes



NOAA (Karl *et al.*, 2010)



Navigating Sea Level Rise Uncertainty







Planning for an Uncertain Climate Future



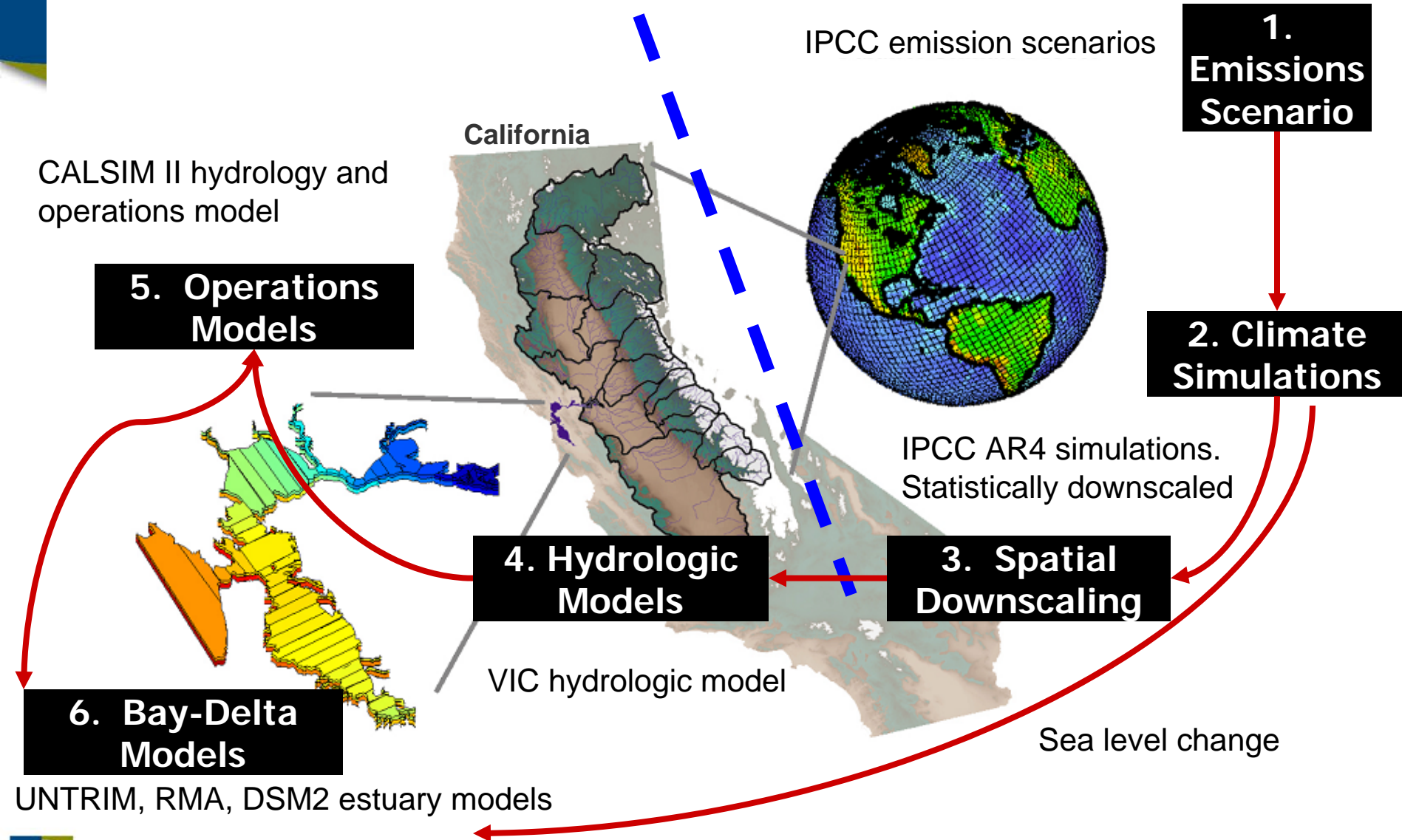
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Incorporating Climate Projections in Water Planning

-  Various approaches have been applied to address the uncertainty with respect to climate change
-  Many projections, some consistency, but significant uncertainty
-  Scenarios and probabilistic approaches
 - *Scenarios: discrete projections to inform future decision-making*
 - *Ensembles: many projections to allow probabilistic assessment of uncertainty*
 - *Hybrid techniques are often preferred*
-  Cascading technical areas in systems as complex as the Delta require a manageable set of future scenarios

Characterizing Climate Change Impacts – Atmosphere to Ocean

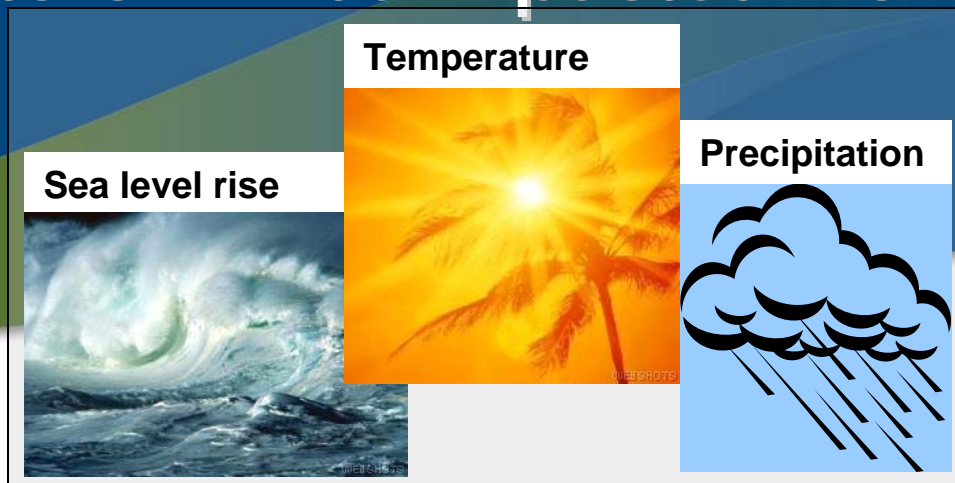
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Adapted from Cayan and Knowles, SCRIPPS/USGS, 2003

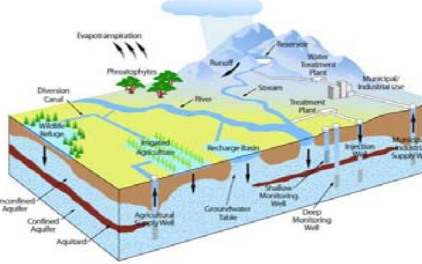
Some Sectors will be Impacted More Than Others

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Impacts on ...

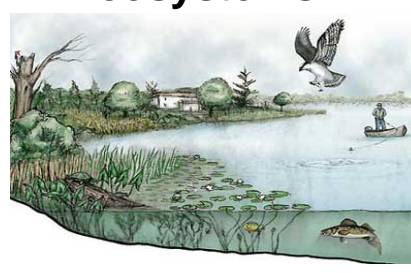
Water Resources



Agriculture



Ecosystems



Flood Management



Water Quality



Coastal Regions



Human Health



Infrastructure



Key Delta Risks to be addressed by Delta Plan

Water Resources

- Reservoir coldwater management
- Reservoir flood control operations
- Delta infrastructure operations, siting, and design
- Operations for salinity management
- Timing of water availability for export
- Changes to water supply reliability

Delta Ecosystem

- Broader area of inundation, upland migration, floodplain inundation
- Changes to hydrograph, temperature
- Timing of spawning and outmigration
- Deeper water with increased predation pressures
- Salinity change effects on vegetation, macro-invertebrates, and invasives

Delta as a Place

- Levee failure/island flooding
- Increased agricultural demands
- Salinity control and management
- Risks to critical infrastructure

Water Quality

- Increasing salinity intrusion
- Changes to delta mixing
- Increased water temperatures
- Changes to dissolved oxygen
- Effects on water treatment and human health

Flood Management

- Levee system fragility under sea level changes
- Increases in extreme events
- Loss of tidal marsh “surge” protection
- Reservoir and bypass flood operations

Climate Risk and Adaptation Framework Needed

5. Monitor Effectiveness & Update Strategies

1. Early Planning & Climate Data Access

Climate Risk & Adaptation Planning Framework



4. Implement Strategies

2. Assess System Vulnerability & Risk

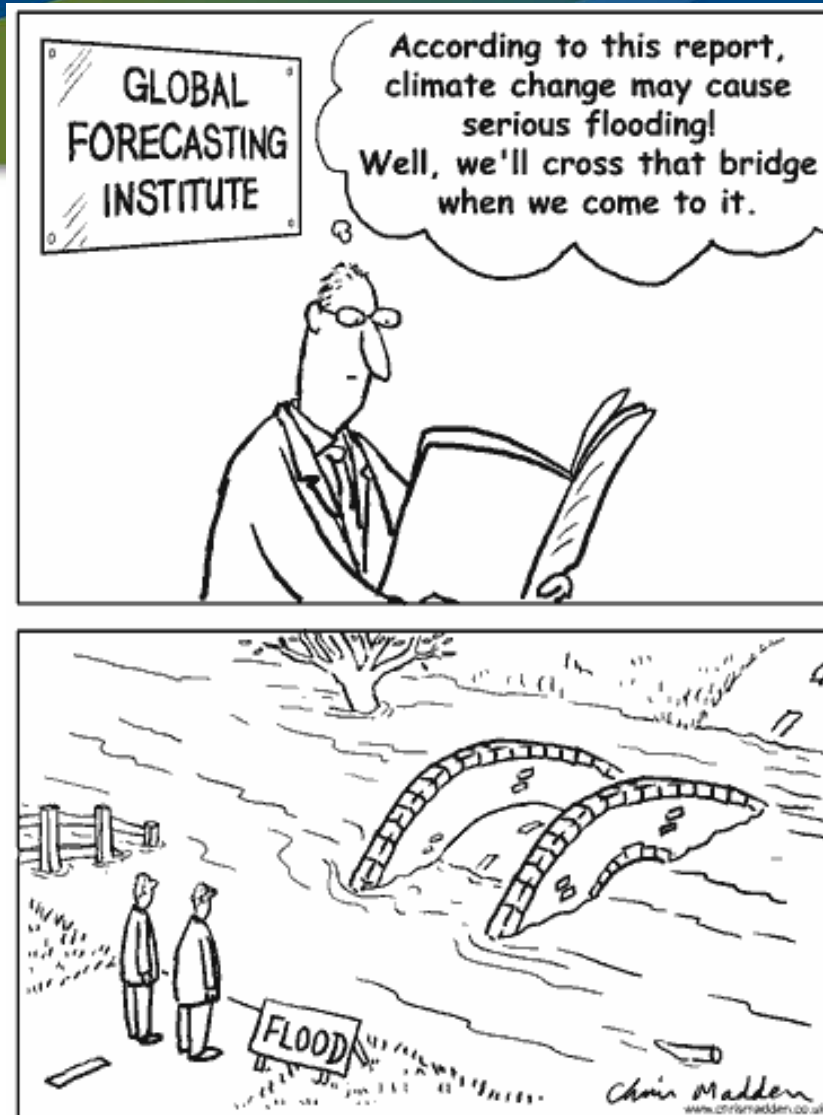
3. Develop Adaptation Strategies

CLIMATE CHANGE AFFECTS THE ENTIRE WATER CYCLE. CONSEQUENTLY, REMEDIES MUST ADDRESS THE INTERRELATED NATURE OF WATER CYCLE COMPONENTS AND FOCUS ON INTEGRATED SOLUTIONS.

Adaptation is a Mix of Technical and Policy

-  Science and technology help identify the vulnerabilities and risks
-  Management and policy need to respond to such risks
 - *Federal policy is developing, but fragmented*
 - *State policy and strategies are advancing rapidly*
 - *Multiple jurisdictional areas: Bay, Delta, floodplains, uplands*
 - *Multiple resources (water supply, flood, ecosystem, delta ag, etc) involved with feedbacks between all of them*
 - *Coordinated climate change adaptation strategy for long-term management and infrastructure risk is needed*

Thank you!



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